DRAFT

North of the Delta
Offstream Storage Investigation

Progress Report

Appendix H: Water Exchange Element

April 2000

Integrated
Storage
Investigations

CALFED
BAY-DELTA
PROGRAM

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Offstream Storage Investigation

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Appendix H: Water Exchange Element

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Summary

Opportunities exist for using the entire yield of any one of four potential new offstream storage projects to satisfy agricultural demands while benefiting Sacramento River fisheries through reduced diversions and improved temperature control, if implemented. Such a water exchange program would satisfy local agricultural and environmental demands with stored water providing the quality is sufficient for its intended uses. This study indicates that there is sufficient demand by available purveyors to fully use the annual yield for any one project as shown in Table 1. Meeting established water demands with new supplies would cause a corresponding decrease in the diversions from the river, thus creating additional storage in Lake Shasta for other uses that include enhancing fisheries through timed releases and temperature control and satisfying current and future delta outflow requirements.

Table 1. Project Yield, Potential Exchange Demand and Surface Supplies
(1,000 acre-feet)

Project	Annual Yield[1]	Demand[2]	Surface Supplies[2]
Red Bank	41	1,194	1,285
Thomes-Newville	195 - 464	1,169	1,259
Sites	238 - 324	710	752
Colusa	341 - 486	710	752

[1] Represents the potential average annual increase in water supply over the 1922 through 1994 study period range.
[2] Represents an average year condition.

For each of the four projects, the Tehama-Colusa Canal system, including Corning Canal, provides the most promising network for making deliveries since this system is fully developed and deliveries are closely regulated under Central Valley Project contracts. This would be considered the first priority of use. The second priority of use lies within the Glenn-Colusa Irrigation District service area adjacent to the TCC and currently being served via the TCC and Williams Outlet intertie facilities. Through Glenn-Colusa ID facilities, Maxwell ID could be served via existing canals and drains. Depending on the preferred conveyance alternative selection for the U.S. Bureau of Reclamation's Refuge Water Supply Program, both Delevan and Colusa National Wildlife Refuges might also receive supplies through the Tehama-Colusa Canal, thus reducing the current supply that is obtained through Glenn-Colusa ID's direct river diversions during the fall, winter, and spring periods.

The final priority of use would come through delivering water to Reclamation District 108 and River Garden Farms Company via the Colusa Basin Drain, which would require additional facilities and significant

monitoring. This level of priority would also include diverting storage from Newville Reservoir to the upper portion of the Glenn-Colusa ID via Stony Creek, which could then supply Provident ID and Princeton-Codora-Glenn ID. This conveyance would be impacted by substantial conveyance losses if new facilities were not constructed.

Based on the potential magnitude of costs for making deliveries, the first priority of use would require no capital expenditures; the second priority of use would require some capital expenditures based on the need for additional conveyance capacities; and the third priority would require capital expenditures for constructing diversion and conveyance structures combined with the potential for significant conveyance losses. The agricultural demands available for each of these priorities of use are shown in Table 2.

Table 2. Potential Average Annual Demand by Priority of Use

(1,000 acre-feet)

Project	Priority of Use		
	First	Second	Third
Red Bank	263	340	591
Thomes-Newville	238	340	591
Sites	171	340	199
Colusa	171	340	199

Meeting a portion of these demands through water exchanges would potentially change or eliminate the time period for lowering of the Red Bluff Diversion Dam Gates as well as reduce the diversions at Glenn-Colusa ID's pumping plant. These benefits extend not only to environmental enhancement, but to farmers through improved timing, reliability, and temperature of water supplies. This program provides all-around benefits for its potential users.

Introduction

Under the North of Delta Offstream Storage Investigation, four potential projects are currently under review to add additional annual yield to the Sacramento River basin. Located in the westside foothills of the Sacramento Valley extending from west of Red Bluff to northwest of Williams, the projects from north-to-south are the Red Bank Project, Thomes-Newville Project, Sites Project, and Colusa Project (see Figure 1). The objective for each project is to capture surplus flows from tributaries to and/or the main stem of the Sacramento River for conveyance to the offstream storage facilities. The conceptual plans to date identify storage projects ranging from 250 to 3,000 taf in capacity with average annual yields of 41 to 486 taf (see Table 3). With these potential yields, this report investigates the opportunities and benefits of using the newly developed supplies to directly offset diversions from the Sacramento River during critical periods of the year.

Figure 1. Overview of the North of Delta Offstream Storage Facilities

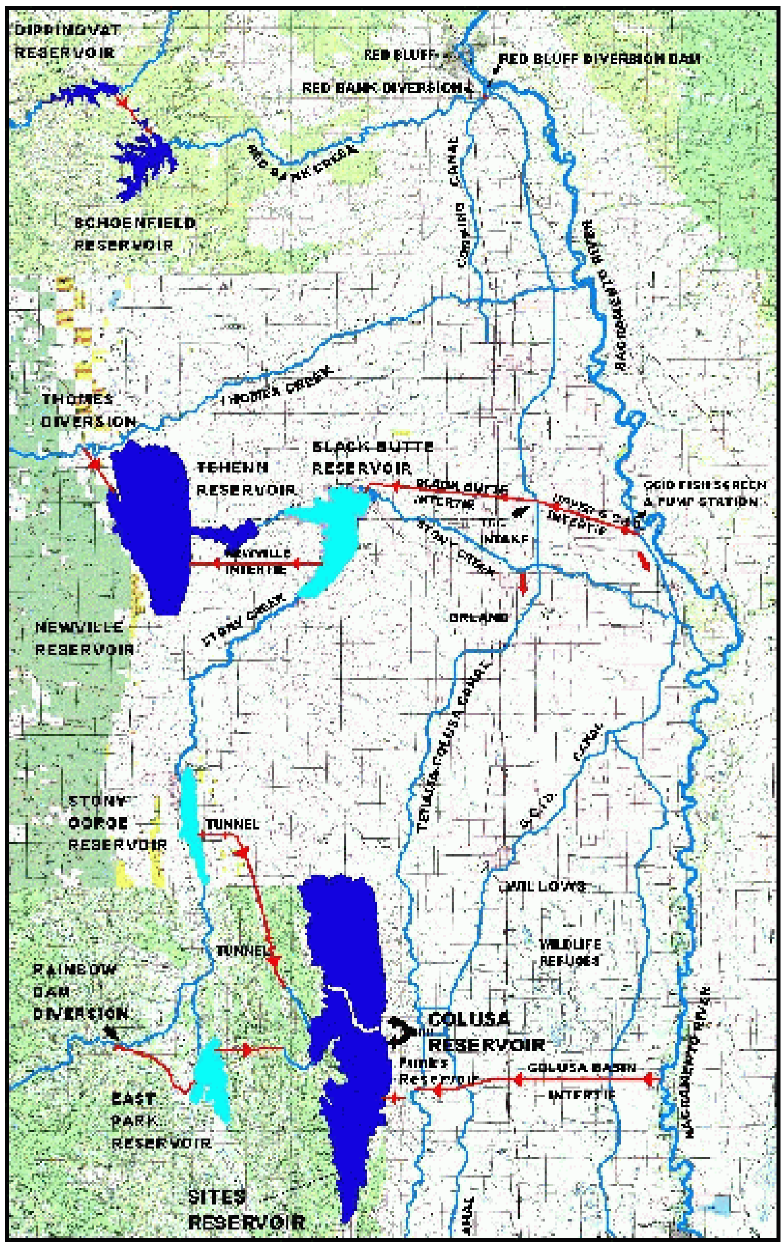


Table 3. Potential Project Storage/Yield
(1,000 acre-feet)

Project	Storage	Annual Yield[1]
Red Bank	250	41
Thomes-Newville	1,900 - 3,000	195 - 464
Sites	1,800	238 - 324
Colusa	3,000	341 - 486

[1] Represents the potential average annual increase in water supply over the 1922 through 1994 study period range.

The Water Exchange Element seeks to identify potential users who could substitute newly developed project yield for direct diversions from the Sacramento River. The potential users are located in the northwestern Sacramento Valley extending 106 miles from Red Bluff in the north to (but not including) Cache Creek in the south. Covering nearly 1,800 square miles, the area is bordered by the Sacramento River on the east and the Coast Range Foothills on the west (see Figure 1). Within the study area, irrigated agricultural development occupies 675,000 acres of land and creates an estimated surface water and groundwater demand of 2,200,000 acre-feet as shown in Table 4. This report presents information on the various aspects of the study area that include the current land use, agricultural water demands, refuge demands, potential water purveyors, project service areas, and program benefits.

Table 4. Study Area Agricultural Acreage and Water Demand

Source	Acreage (1,000 acres)	Demand (1,000 acre-feet)
Surface water	463	1,600
Groundwater	212	600
Total	**675**	**2,200**

Land Use

The land use data used in this study shows the current source of water applied to each field, either surface water, groundwater, or a mix of the two. Acreage data are summarized by crop and water source. The basic unit of analysis is the individual water purveyor. The net irrigated acreage reported has been adjusted to remove the effects of roads, canals, ditches, etc., within the mapped field boundaries.

The evaluation of existing water demands and irrigated crop acreage is based on dwr’s land use surveys. The study area data are based on the following land use surveys: Colusa County, 1993; Glenn County, 1993; Tehama County, 1994; and Yolo County, 1997. These years represent the most recently available data. However, planted acreage has increased yearly following the return to full supply availability after the 1987-92 and 1994 droughts.

The study area encompasses nearly 605,000 acres of irrigated crop land as well as acreage dedicated to refuge and private wetland usage. Of the total irrigated crop land shown in Table 5, an estimated 418,000 acres have the potential to use surface water in any one year (the sum of acreages served from surface and mixed water sources). Sources of surface water range from direct diversions from the Sacramento River and Stony Creek to diversions of drain water from the Colusa Basin Drain.

Table 5. Estimated Study Area Irrigated Acreage
(acres)

Water Source	Cropped	Fallow/Idle	Marsh
Surface Water	367,352	33,149	20,634
Mixed Water	50,937	3,595	3,578
Groundwater	186,369	9,884	0
Total	**604,658**	**46,628**	**24,212**

An overview of the crop and water source mapping is presented in Figures 2 and 3, respectively, for lands north of the potential Colusa Basin Intertie and Figures 4 and 5, respectively, for lands south of the potential Colusa Basin Intertie.

Agricultural Demands

The applied water method is used to estimate the amount of water that must be delivered to each field to satisfy the crop's consumptive use requirement. Since the applied water is calculated by water source for each crop, the amount of surface water and/or groundwater utilized on each field within a water purveyor service area or basin can be estimated. When the total applied surface water is summarized for individual water purveyors, it is then compared with diversion data to estimate the quantity of reuse occurring within the service area. Typically, reuse is associated in greater degree with surface water application. Because of the greater cost to the farmer and the well's proximity to the point of application in the Sacramento Valley, groundwater application is generally more efficient, which can reduce on-field losses. This can reduce the amount of potential reuse downstream. The total applied groundwater essentially equals total groundwater extraction. This has become the primary method to determine groundwater extraction by DWR in the northern Sacramento Valley, especially since the aquifer recharge characteristics in some of the areas and the relatively few spring and fall depth to groundwater measurements limit the ability to use other methods to calculate groundwater extraction.

Figure 2. North of Colusa Basin Intertie Agricultural Land Use

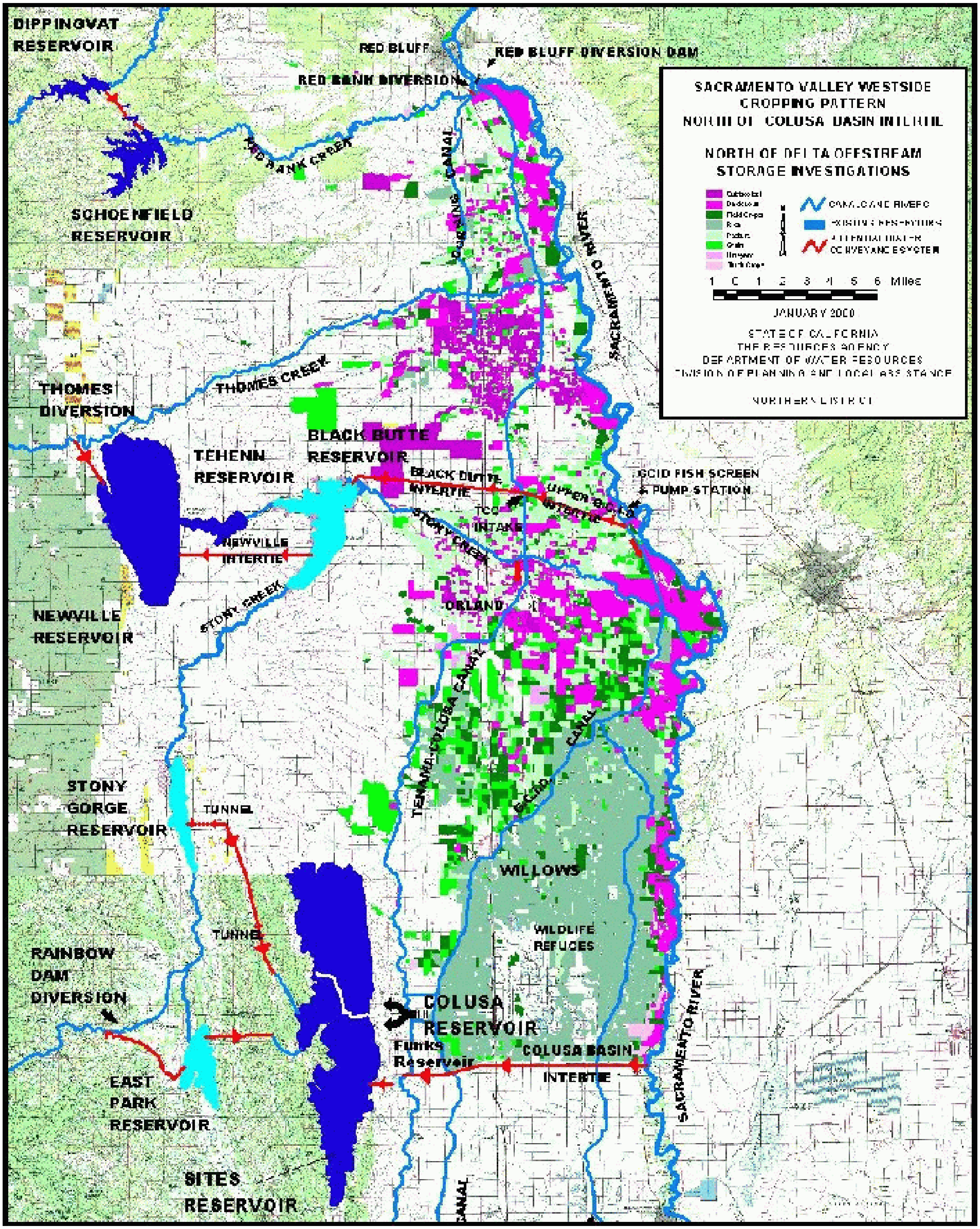


Figure 3. North of Colusa Basin Intertie Irrigation Water Source

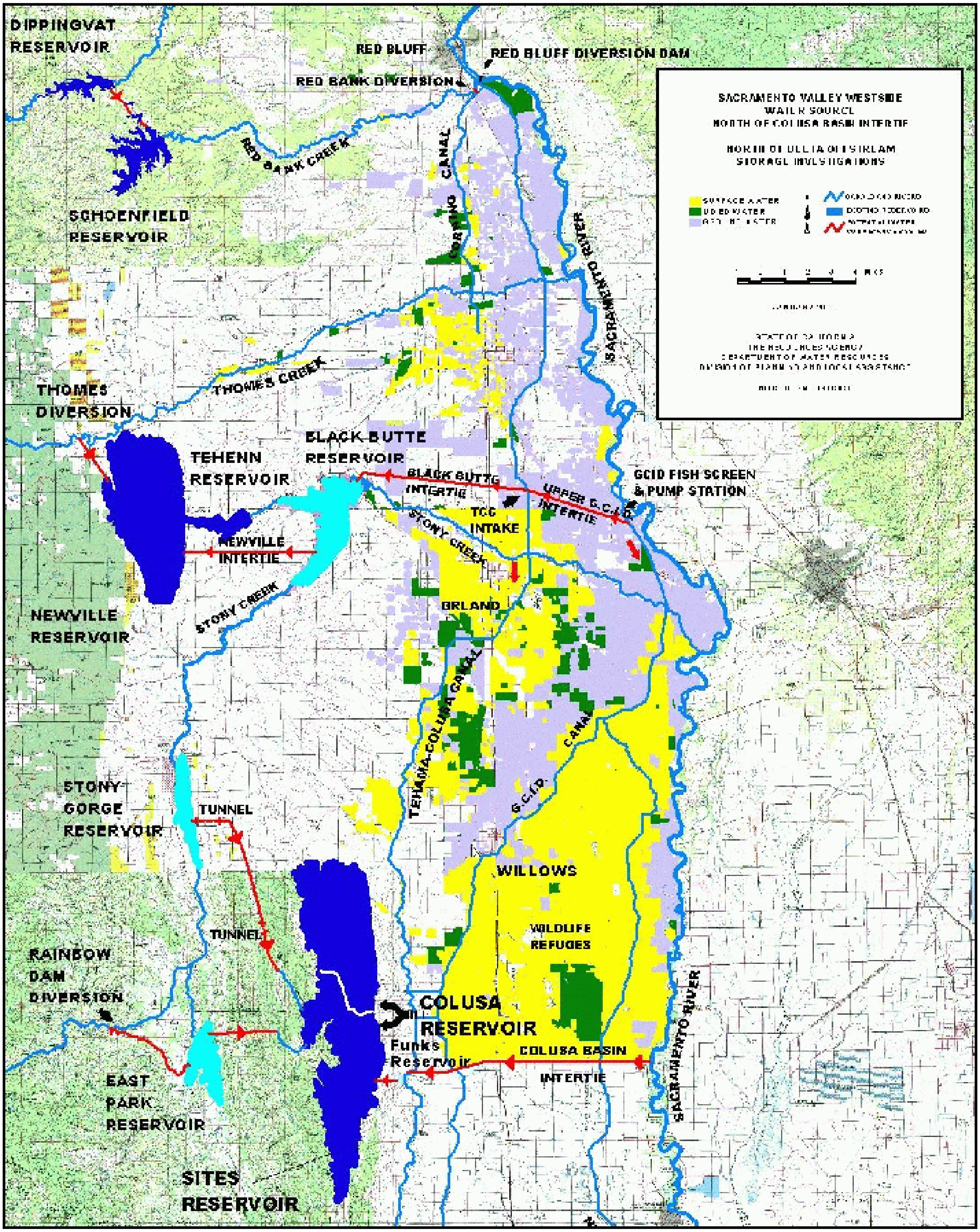


Figure 4. South of Colusa Basin Intertie Agricultural Land Use

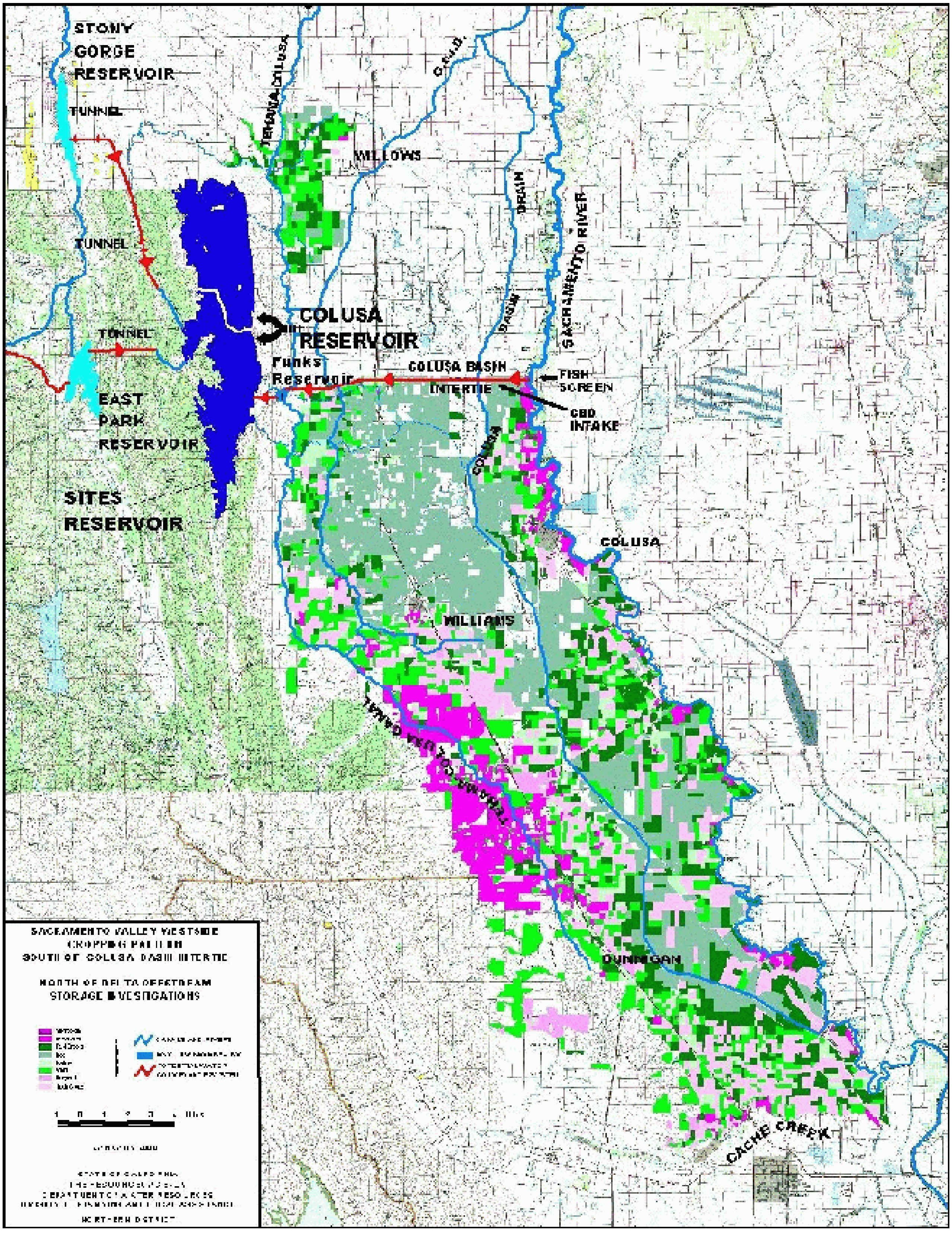
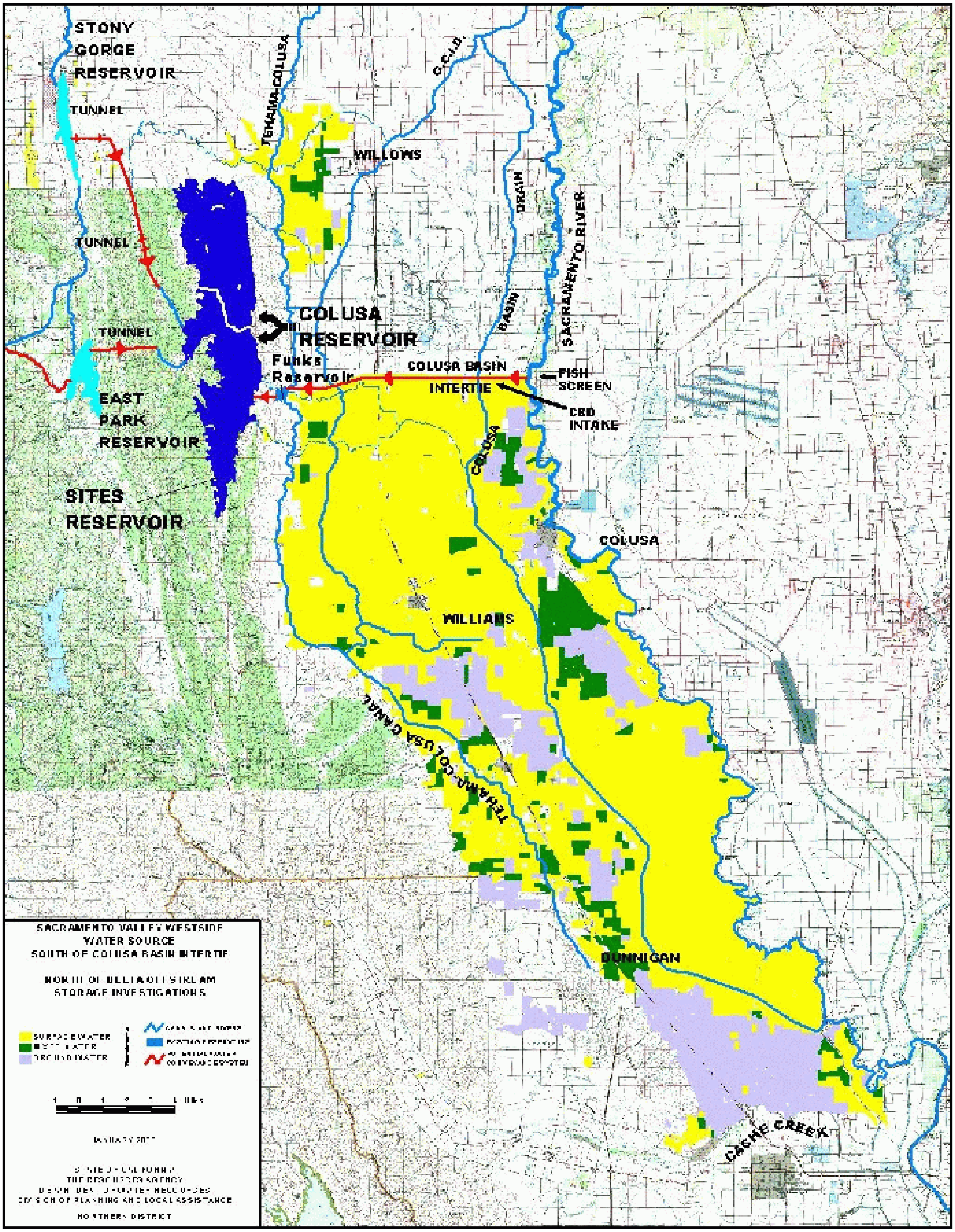


Figure 5. South of Colusa Basin Intertie Irrigation Water Source



For each reported crop category in each region of the study area, a unit evapotranspiration of applied water (ETAW) was derived by using pan evaporation data, crop coefficients, precipitation data, and soil moisture-holding characteristics. Crop coefficients are used to convert pan evaporation data to potential evapotranspiration for each crop category. The difference between potential crop evapotranspiration and effective precipitation is the crop's ETAW. Effective precipitation is determined in part by evaluating the amount of precipitation that would have percolated to the rootzone of the crop being analyzed. The soil moisture-holding characteristics, which are typically defined as the water holding capacity per foot of depth for each soil series, are used in combination with precipitation to determine the soil's potential for storing effective precipitation at any point prior to and during the growing season. This results in a crop-specific calculation of effective precipitation.

For each crop, a soil moisture banking calculation is used to evaluate monthly changes in soil moisture storage due to rainfall, soil surface evaporation, evapotranspiration by vegetation, and application of irrigation water. Working on a water year basis and knowing the specific characteristics about a crop, this banking system computes the storage of precipitation in the rootzone, percolation of precipitation below the rootzone, and extraction by means of soil surface evaporation or crop evapotranspiration on a month by month basis for the entire growing season. Starting with an initial soil moisture storage and then continuing the banking system throughout the season, all computed deficits in soil moisture storage resulting from crop evapotranspiration result in the need for applied irrigation water, which is ETAW.

Applied water requirements for each crop were determined by the use of ETAW and irrigation efficiency data that are summarized in Table 6. Irrigation efficiencies used herein are seasonal application efficiencies developed for each crop category by water source type (i.e., surface, ground). Applied water data have been collected for many years from various water purveyors, individual farmers, and farm advisors throughout the Sacramento Valley. These measured data are used to compute irrigation efficiencies that are compared with ones developed from previous studies and by DWR staff who have the knowledge of methods, practices, and trends in irrigation within the Sacramento Valley.

Table 6. ETAW, Irrigation Efficiencies, and Applied Water

Crop	Unit ETAW (af/acre)	On-Field Surface Water Efficiency	On-field Groundwater Efficiency	Unit Applied Surface Water (af/acre)	Unit Applied Groundwater (af/acre)
Grain	0.7	70%	85%	1.0	0.8
Rice	3.2	58%	63%	5.5	5.1
Dry Beans	1.8	65%	70%	2.8	2.6
Alfalfa	3.5	70%	75%	5.0	4.7
Tomatoes[1]	1.8	70%	75%	2.9	2.7
Melons	1.1	70%	75%	1.6	1.5
Almonds	2.7	75%	80%	3.6	3.4

[1] Applied water includes cultural practice of pre-irrigation and weed control.

Once the irrigation efficiencies are verified and a reasonable estimate for the entire subregion is achieved, they are applied to the unit ETAW values to determine unit applied water, which represents the average amount of irrigation water applied to each acre of land. The applied water values are then reviewed by local farm advisors, water purveyor personnel, and/or farm managers for reasonableness. Then the product of the unit applied water values and the net irrigated acreage data result in the total applied water demand by crop for a given area.

Wildlife Demands

DWR's Land and Water Use programs routinely evaluate land uses that contribute to the management of waterfowl. Typically, waterfowl are managed through federal/State refuges, private wetlands/duck clubs and the flooding of rice lands. DWR's regular land use surveys document the amount of acreage managed and the types of habitat created. In general, the surveys document seasonal marsh, permanent marsh, upland habitat, and forage crop conditions that are managed throughout the year, as well as rice acreage flooded to provide forage for migrating and wintering waterfowl.

In addition to surveys, DWR has relied upon several available sources of information for determining habitat acreage and applied water requirements, primarily: U.S. Fish and Wildlife Service estimates of harvested rice fields flooded for waterfowl; DWR's information files; U.S. Bureau of Reclamation's report *on Refuge Water Supply Investigation, Central Valley Basin, California* (1989); interviews with federal/state refuge managers, private duck club operators, wildlife biologists, water purveyors, and farm advisors; and DWR's winter and summer land use surveys and studies. Year-to-year analyses rely on the aforementioned sources as well as the judgement and knowledge of DWR staff.

To assess the applied water requirements, habitat acreage is divided into four categories: seasonal marsh (flooded for 6 months); permanent marsh (flooded for 9 or 12 months); rice fields (burned, chopped, or rolled then flooded for 6 months); and millet (feed for waterfowl). The demands for each category consist of a combination of the requirements listed below:

Flood-up	-	The amount of water required to recharge a soil profile and flood a field to a specific depth.
Evaporation	-	The amount of evaporation occurring from the flooded field and/or wetted soil surface during the period being analyzed.
Percolation	-	Monthly percolation rates are based on the habitat's specific soil characteristics. A portion of this will create seepage to drains while a smaller portion can percolate to the aquifer depending on conditions.
Circulation Requirement	-	Also known as "flow through water", this requirement helps to prevent diseases such as botulism and cholera from occurring. It also creates outflow from a habitat field.

A major portion of the managed wetlands within the study area are centered within the Sacramento National Wildlife Refuge Complex (Sacramento, Delevan, and Colusa NWRs). USBR planning reports identified the necessary water supplies for optimum habitat management through Level 4 designation as shown in Table 7. The 1992 Central Valley Project Improvement Act guaranteed Level 4 supplies for each of the refuges by 2002. Further investigation will be needed to quantify demands for privately managed wetlands.

Table 7. CVPIA Level 4 Water Supplies for the Sacramento National Wildlife Refuge Complex[1] (in acre-feet)

Month	Sacramento NWR	Delevan NWR	Colusa NWR
January	1,250	2,375	1,200
February	1,250	1,875	800
March	1,250	625	350
April	300	125	770
May	2,250	625	1,440
June	2,750	1,250	2,500
July	4,200	2,250	2,880
August	6,850	3,125	2,880
September	8,700	4,325	3,840
October	8,900	4,375	3,840
November	8,800	4,375	2,400
December	3,500	4,675	2,100
Total	**50,000**	**30,000**	**25,000**
Dec - Apr	7,550	9,675	5,220

[1] United State Bureau of Reclamation. *Report of Refuge Water Supply Investigations*. March 1989.

Water Purveyors

Several criteria were used in selecting the most promising service areas for potential water exchanges. The most important criterion for potential participation in water exchanges is that a user must have a riparian, appropriative, or contract right that guarantees delivery of the specified amount on an annual basis, with the exception of curtailments during drought years. A majority of lands using surface water from the Sacramento River are served under settlement and/or water service contracts with USBR. Secondly, the user must lie within a reasonable distance of major conveyance facilities and have access to them. The need to build additional conveyance facilities must be minimized to hold down project costs. Surface water purveyors are ideally preferred since they typically distribute supplies to multiple users. It is not practical to supply individual users since this would often create higher operating costs in addition to possibly necessitating the construction of new facilities. Finally, the offstream storage supply should only provide greater reliability and timing of existing supplies and will not make up for any deficient water rights.

The water purveyors considered by this study are shown in Figure 6 on pages 14 and 15 and summarized in Table 8, along with their irrigated acreages, water supplies and typical crops. The Orland Unit Water Users Association is not included as a purveyor since it supplies are already obtained within the basin from Stony Creek itself and storage in East Park, Stony Gorge, and Black Butte Reservoirs.

Table 8. Acreage and River Diversion Summary by Water Purveyor

Service Areas	Acreage[1] Irrigated / Idle / Marsh (acres)	Annual River Diversions[2] (acre-feet)	Typical Crop Types
Proberta WD	1,646 / 538 / 0	1,408 - 6,557	rice, pasture, prunes, misc. field, almonds
Thomes Creek WD	1,545 / 596 / 0	1,545 - 8,246	rice, alfalfa, pasture, almonds, prunes, olives
Corning WD	6,960 / 1568 / 15	5,782 – 27,120	olives, eucalyptus, prunes, almonds, pasture, rice, grain
Kirkwood WD	354 / 90 / 0	105 - 834	grain, alfalfa, pasture
Orland-Artois WD	25,466 / 3,044 / 0	13,099 - 83,365	grain, rice, corn, misc. field, alfalfa, almonds, olives
Glenn-Colusa ID	122,798 / 15,104 / 1,922	475,908 - 874,159	grain, rice, misc. field, pasture, tomatoes, melons
Glide WD	5,654 / 428 / 0	3,746 – 17,203	grain, rice, misc. field
Kanawha WD	13,019 / 114 / 0	10,573 - 41,507	grain, rice, sugar beets, corn, misc. field, alfalfa, pasture
Princeton-Codora-Glenn ID	9,798 / 451 / 41	37,080 - 71,061	rice, misc. field, misc. truck, misc. orchard
Provident ID	14,321 / 962 / 38	23,138 - 54,147	rice
Holthouse WD	376 / 189 / 0	479 – 2,583	grain, pasture, melons
4-M WD	1,101 / 241 / 0	1,512 - 3,451	grain, misc. field, alfalfa, melons
Maxwell ID	4,803 / 247 / 2437	0 - 18,876	rice, seasonal marsh, permanent marsh
Glenn Valley WD	580 / 40 / 0	346 – 1,266	grain, rice, dry beans, melons
La Grande WD	1,246 / 114 / 0	2,225 - 7,490	grain, rice, misc. field, pasture
Davis WD	931 / 130 / 0	1,233 - 5,739	grain, tomatoes, melons
Westside WD	11,555 / 341 / 14	13,959 - 39,509	grain, rice, field crops, tomatoes, melons, almonds
Cortina WD	486 / 85 / 0	346 – 1,889	grain, alfalfa, tomatoes, almonds
Colusa County WD	32,659 / 2,515 / 0	17,504 - 65,397	grain, rice, misc. field, tomatoes, melons, almonds, grapes
Reclamation District 108	49,178 / 1,090 / 16	90,516 – 205,432	grain, rice, misc. field, tomatoes, melons
Dunnigan WD	7,916 / 810 / 0	4,388 – 15,996	grain, corn, misc. field, alfalfa, tomatoes, melons, almonds
River Garden Farms Co.	6,708 / 91 / 0	5,897 – 30,204	rice, misc. field, tomatoes, melons

[1] Acreage based on DWR land use surveys: Colusa County, 1993; Glenn County, 1993; Tehama County, 1994; and Yolo County, 1997.

[2] 1970-98 data from USBR.

Figure 6. Water Purveyors

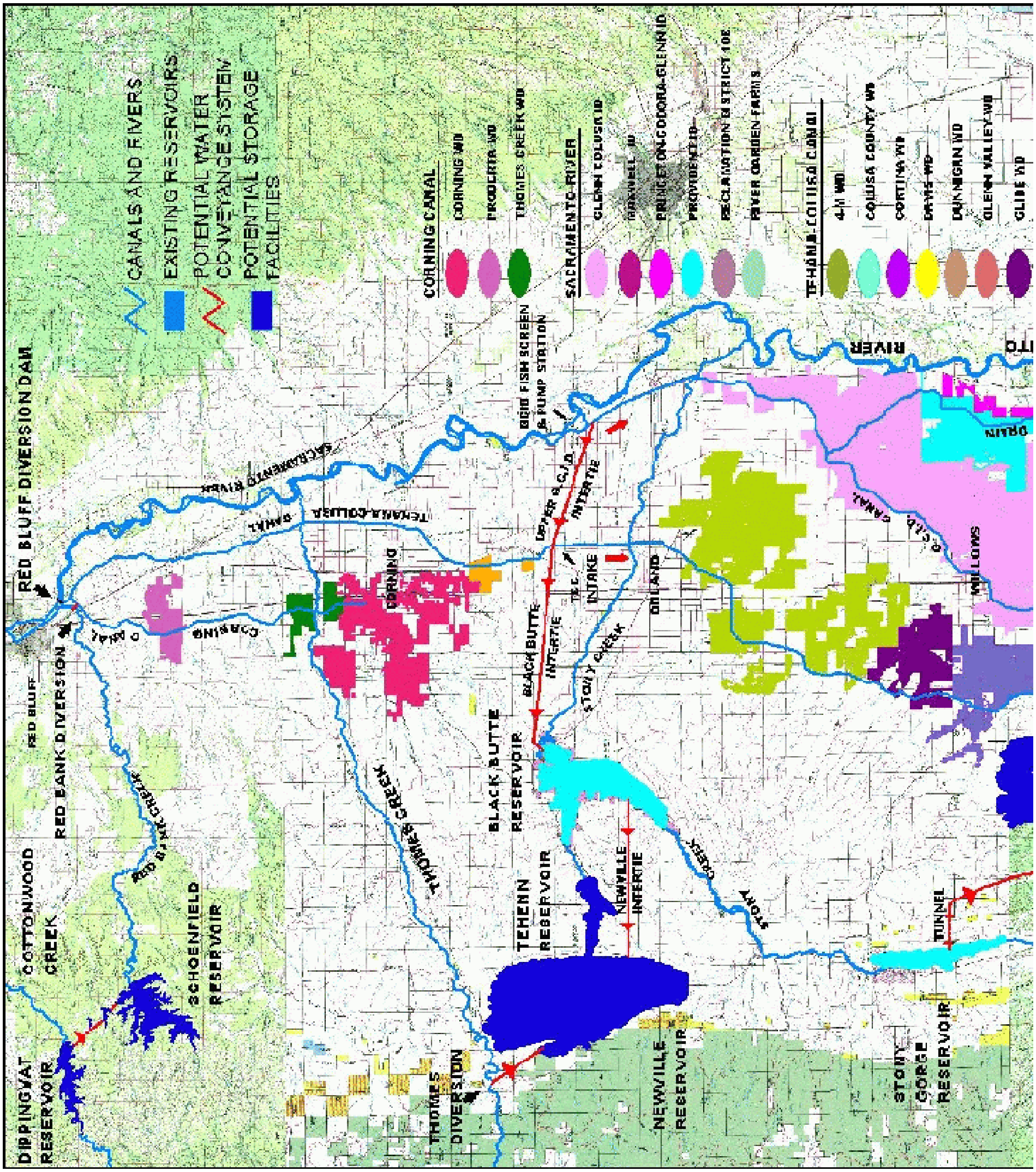
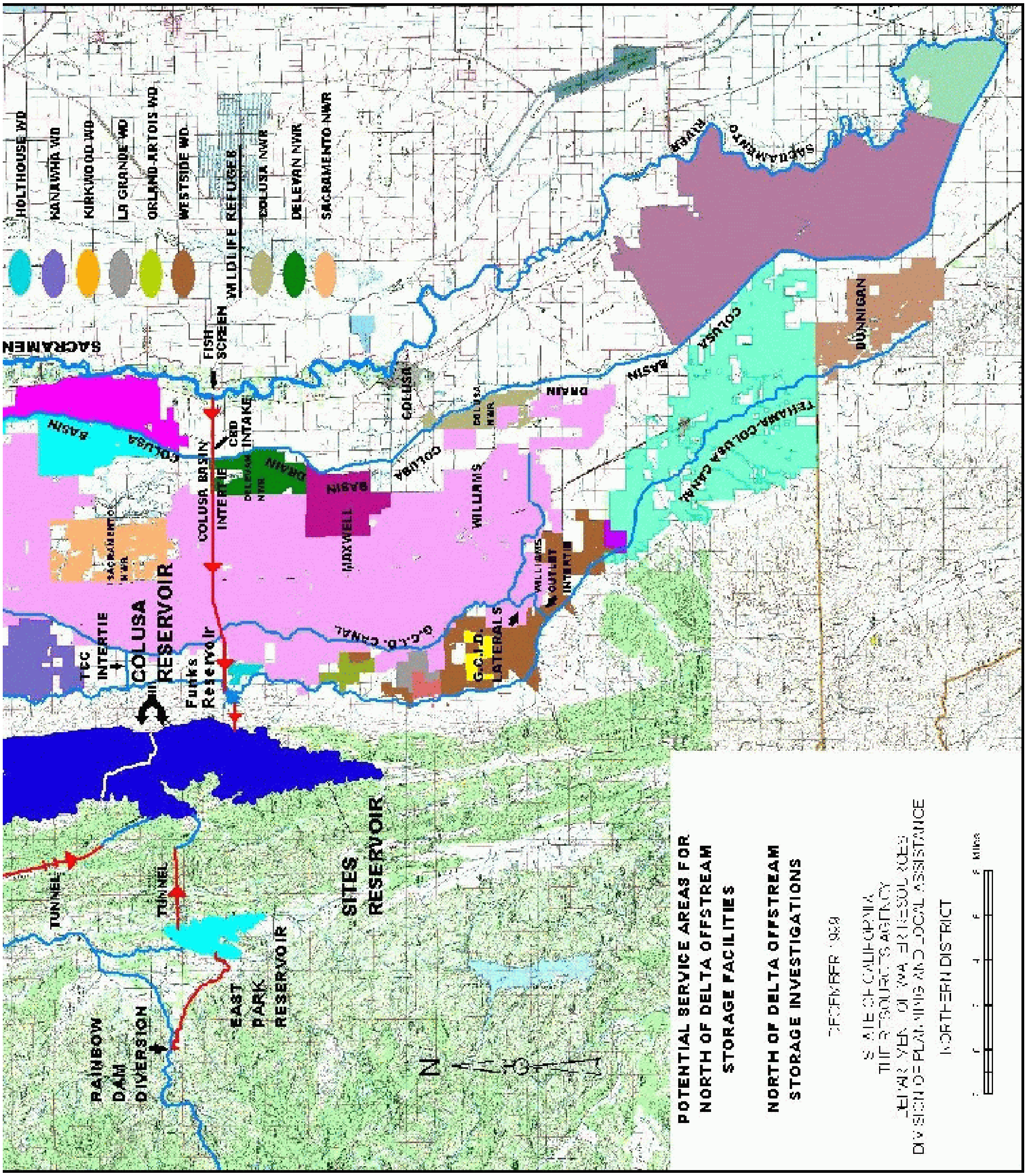


Figure 6. Water Purveyors (cont.)



Potential Exchange Service Areas

One of the primary purposes for this study is to indicate and rank the potential exchange participants that would create the least amount of need for developing new infrastructure, thus minimizing project costs. For the water purveyors previously identified, the total average demands and supplies are summarized by offstream storage project in Table 9. Table 10 summarizes the demands by month.

Table 9. Agricultural Surface Water Demands and Supplies by Potential Exchange Service Area
(1,000 acre-feet)

Project	Demand	Surface Supplies
Red Bank	1,194	1,285
Thomes-Newville	1,169	1,259
Sites	710	752
Colusa	710	752

Table 10. Monthly Agricultural Surface Water Demand in Potential Exchange Service Areas
(1,000 acre-feet)

Project	Offstream Storage Projects			
	Red Bank	Thomes-Newville	Sites	Colusa
January	0.0	0.0	0.0	0.0
February	0.0	0.0	0.0	0.0
March	7.5	7.5	6.1	6.1
April	28.8	27.8	20.2	20.2
May	130.4	127.0	77.7	77.7
June	256.0	250.8	150.6	150.6
July	310.3	304.3	185.0	185.0
August	263.3	258.2	155.5	155.5
September	181.8	178.9	106.0	106.0
October	15.0	13.4	8.3	8.3
November	0.7	0.7	0.5	0.5
December	0.0	0.0	0.0	0.0
Total	**1,193.8**	**1,168.6**	**709.9**	**709.9**

Red Bank

The Red Bank Project is the northernmost of the four potential offstream reservoir and conveyance facilities currently under study. The Red Bank Project would capture and store excess flows from the South Fork of Cottonwood Creek, a tributary to the Sacramento River near the town Cottonwood at the northern end of the Sacramento Valley. With a storage potential of nearly 250 taf and an annual yield of 41 taf, this project could provide water service to the Corning and Tehama-Colusa canal system. Water would be released to Red Bank Creek from Schoenfield Dam and conveyed downstream to a diversion facility near, but upstream from, its confluence with the Sacramento River.

This proposed facility would then convey water to the TCC, where it could be used downstream or pumped to the Corning Canal. No additional facilities would be needed downstream on the Tehama-Colusa or Corning Canals to deliver water to existing water purveyors. Since Red Bank Creek often becomes dry by June and remains in that condition until after the fall rains have adequately recharged the drainage system and creek bed, the optimum conveyance of stored water would occur during periods when the surface flow is occurring. Conveyance during the hot, dry summer would be less effective due to evaporation and potential percolation to groundwater.

Combined, the Tehama-Colusa and Corning Canal service areas receive average surface water deliveries of 319 taf (as shown in Table 11) for roughly 339 taf of demand that includes a portion of Glenn-Colusa ID. Ideally, the Red Bank Project could be used to supply early irrigation season demands, thus delaying the need for the lowering of the Red Bluff Diversion Dam gates. Combining the Red Bank Project yield with the present 405 cfs pumping capacity (24,400 acre-feet per month maximum diversion) at the Red Bluff Diversion Dam and available CVP storage in Black Butte Reservoir would allow the Red Bluff Diversion Gates to raised until approximately mid-June during average year conditions. During dry year scenarios, this combined supply may only satisfy demands through mid-May, but would alleviate the need for temporary gate closures prior to May 15. This would at least increase the supply reliability to the farmers on these systems while enhancing the fisheries on the upper Sacramento River.

Thomes-Newville

The Thomes-Newville Project would consist of a reservoir on the North Fork of Stony Creek and a diversion facility located on Thomes Creek for conveyance to the reservoir. To maximize yield, additional water could be captured from the high flows on the Sacramento River. Up to 3,000 cfs could be diverted at the Red Bluff Diversion Dam, conveyed southward via the TCC to a new "Black Butte Intertie" that would convey water from the canal to Black Butte Reservoir. From Black Butte Reservoir, the supply would be pumped to Newville Reservoir via the Newville Intertie facility shown in Figure 6. Another 3,000 cfs could be diverted through the Glenn-Colusa ID Pumping Plant (which will have state-of-the-art fish screen facilities) at Sacramento River Mile 154.8 and conveyed via a new facility identified as the Upper GCID Intertie to the Black Butte Intertie.

Table 11. Average Monthly Surface Water Deliveries[1]
(1,000 acre-feet)

Month	Corning Canal	Tehama-Colusa Canal	Total
January	0.0	0.4	0.4
February	0.0	1.3	1.3
March	0.3	5.2	5.5
April	1.2	20.9	22.1
May	4.0	48.9	52.9
June	5.5	53.2	58.7
July	6.2	65.2	71.4
August	6.0	58.1	64.1
September	3.8	21.2	25.0
October	1.4	12.7	14.1
November	0.4	2.6	3.0
December	0.0	0.8	0.8
Total	**28.8**	**290.5**	**319.3**

[1] Average of 1985-89, 1993 and 1995-98 (non-drought years) deliveries.

If no intertie facilities were constructed, yield from Newville Reservoir would be released via North Fork Stony Creek to Black Butte Reservoir, where it would then be released to Stony Creek. Roughly 10 miles downstream from Black Butte Reservoir, the supply would be diverted to the TCC via the existing Constant Head Orifice structure. If the Black Butte Intertie were constructed, it could convey flows back to the Tehama-Colusa Canal, thus avoiding the need for additional structures in Stony Creek.

Introducing offstream storage supplies at this point on the TCC would allow for service to 13 downstream surface water purveyors. Also, based on the canal's geometry and slope, water could be conveyed upstream to Kirkwood Water District. Downstream, Glenn-Colusa ID, which diverts a relatively small portion of its current total supply through the TCC and Williams Outlet Intertie facilities, could supply a portion of its lower service area.

If the available yield exceeds the aforementioned service area demands, the remaining supply could be conveyed downstream via either Stony Creek or the GCID Intertie for diversion into the GCID Canal for use in the upper portion of the Glenn-Colusa ID's service area above the TCC Intertie and in Princeton-Codora-Glenn ID and Provident ID via releases to the Colusa Basin Drain. Other options could include releasing water from the end of the GCID Canal to the Colusa Basin Drain for conveyance to Reclamation District 108 and River Garden Farms Company.

Sites/Colusa

Located approximately 6 miles west the town of Maxwell, both the Sites and Colusa projects would provide offstream storage in the Antelope Valley portion of the Stone Corral and Funks creek basins. Colusa Reservoir will be a larger version of Sites Reservoir incorporating additional storage facilities to the north.

Various combinations of diversions from the Stony Creek system, the

Tehama-Colusa Canal, the Colusa Basin Drain, and the Sacramento River would be included to fill the potential 1.2 to 1.9 maf Sites Reservoir and the 3.0 maf Colusa Reservoir. Potential facilities (Figure 6) could include: canals and tunnels from both East Park and Stony Gorge reservoirs on Stony Creek; a Funks Intertie facility that would convey water from the TCC at Funks Reservoir to the project reservoir; and a combination of Colusa Basin Intertie reaches that could connect the GCID Canal, Colusa Basin Drain and/or the Sacramento River to the Funks Reservoir. At minimum, the TCC and the GCID Canal could divert surplus Sacramento River flows with a combined capacity of nearly 5,000 cfs at the existing Funks Reservoir site on the Tehama-Colusa Canal. In reverse, the Funks and Colusa Basin interties could then convey stored surface water to users within the Colusa Basin.

The TCC provides the most convenient potential service area without the need for any additional conveyance facilities. Downstream TCC water users would include: (north-to-south) Glenn-Colusa ID (via TCC and Williams Outlet interties), Holthouse WD, 4-M WD, La Grande WD, Glenn Valley WD, Davis WD, Westside WD, Cortina WD, Colusa County WD, Dunnigan WD. The TCC service area could include the potential service via reverse gravity flows to a portion of Glide WD at TCC Mile 48.52 and all of Kanawha WD that lies upstream from Funks Reservoir. If the Colusa Basin Intertie were developed from the Colusa Basin Drain to the Glenn-Colusa ID Main Canal for diverting excess winter flows in the drain, this same intertie could convey water to the Colusa Basin Drain in combination with the GCID Canal to supply to Maxwell ID, Reclamation District 108 and River Garden Farms Company. Currently, Reclamation District 108 has some diversion capacity at its Riggs Ranch Pumping Plant on the Colusa Basin Drain while River Garden Farms Company facilities on the drain have yet to be investigated. In both cases, additional capacity and/or new pumping facilities will need to be constructed if large quantities of water become available.

Supplying Refuges

The offstream storage projects could also increase water supply reliability and reduce the need for direct river diversions during fish migration periods for the Sacramento, Delevan, and Colusa NWRs (see Figure 6). The most opportune period for deliveries is November through April. Deliveries from offstream storage could reduce or eliminate the need for Glenn-Colusa ID to make direct river diversions during this period. However, to deliver these supplies, additional releases will be required to overcome potentially significant conveyance losses.

Sacramento NWR could be supplied only from the Thomes-Newville Project by providing conveyance to the upper portion of the GCID Canal via the Upper GCID Intertie or Stony Creek. Deliveries to both Delevan and Colusa NWRs could be made through the GCID Canal via the TCC and Williams Outlet interties from any one of the potential projects and are contingent upon studies by USBR's for year-round conveyance to meet CVPIA refuge water requirements. Supplies to Delevan NWR could easily be routed from the GCID Canal via Willits Slough/Hunters Creek or Lateral 41-1 to the north end of the refuge. For Colusa NWR, supplies could be routed through Glenn-Colusa ID's laterals or diverted via Willits Creek to the Colusa Basin Drain for diversion at the north end of the refuge.

Summary of Exchange Potential

Table 12 summarizes the analysis of the individual offstream storage projects and their potential exchange service areas. The method of conveyance is highly contingent upon the facilities developed for diverting surplus river and tributary flows to the storage sites. The projects are ranked by the potential for satisfying the demand for a purveyor. In some instances, a portion of the demand met by a purveyor may require minimal or no additional facility costs where as the other portion of the demand may require significant costs for making the deliveries. Costs could include but are not limited to creating additional conveyance capacity in canals, laterals, drains, and/or pumping/diversion facilities.

Benefits

The Water Exchange Element of the Offstream Storage Investigation could create positive benefits to both the environmental and agricultural communities. Once significant environmental issue associated with offstream storage is the introduction of higher temperature water into the network of natural and constructed waterways.

The west side of the Sacramento Valley affords the opportunity to use any one of the project yields to satisfy (through exchange) a portion of nearly 1.2 maf of agricultural demands by 22 local purveyors that have entitlements from the river. The potential exists for the Sacramento National Wildlife Refuge Complex to use these supplies since the refuges receive their supplies through local purveyors identified in this study. Exchange of project yield for existing surface supplies would permit proportional reductions in surface diversions (with appropriate adjustments for conveyance losses involved with this exchange, which have not been determined thus far). The reduction in river diversions would result in additional storage in Shasta Lake for release during periods that would enhance the fish migration, spawning and Delta outflow. Releasing water from Shasta Lake affords the opportunity to better regulate river temperatures and to maintain higher flows in longer stretches of the river.

Table 12. Agricultural Surface Water Demand Conveyance Priority by Purveyor

(1,000 acre-feet)

First Priority (1) - Minimal Cost
Second Priority (2) - Minimal to Moderate Cost
Third Priority (3) - Moderate to Significant Cost

Priority	Water Purveyor	Demand Potential by Project: Red Bank	Thomes-Newville	Sites	Colusa	Method of Conveyance
1	Corning WD	18.4				Corning Canal
1	Proberta WD	3.3				Corning Canal
1	Thomes Creek WD	3.5				Corning Canal
1	Kirkwood WD	0.6	0.6			Tehama-Colusa Canal
3	Glenn-Colusa ID (Upper)	267.6	267.6			Stony Creek / Upper GCID Intertie to GCID Main Canal
1	Orland-Artois WD	58.4	58.4			Tehama-Colusa Canal
1	Glide WD (Upper)	7.5	7.5			Tehama-Colusa Canal
3	Princeton-Codora-Glenn ID	46.3	46.3			Stony Creek / Upper GCID to GCID Main Canal to Colusa Basin Drain
3	Provident ID	78.3	78.3			Stony Creek / Upper GCID Intertie to GCID Main Canal To Colusa Basin Drain
1	4-M WD	2.2	2.2	2.2	2.2	Tehama-Colusa Canal
1	Colusa County WD	73.5	73.5	73.5	73.5	Tehama-Colusa Canal
1	Cortina WD	1.5	1.5	1.5	1.5	Tehama-Colusa Canal
1	Davis WD	1.8	1.8	1.8	1.8	Tehama-Colusa Canal
1	Dunnigan WD	15.9	15.9	15.9	15.9	Tehama-Colusa Canal
2	Glenn-Colusa ID (Lower)	314.1	314.1	314.1	314.1	TCC & Williams Outlet Interties to GCIC Main Canal or Sacramento River Intertie to GCID Main Canal
1	Glenn Valley WD	1.3	1.3	1.3	1.3	Tehama-Colusa Canal
1	Glide WD (Lower)	9.4	9.4	9.4	9.4	Tehama-Colusa Canal
1	Holthouse WD	1.2	1.2	1.2	1.2	Tehama-Colusa Canal
1	Kanawha WD	31.8	31.8	31.8	31.8	Tehama-Colusa Canal
1	La Grande WD	6.1	6.1	6.1	6.1	Tehama-Colusa Canal
2	Maxwell ID	26.1	26.1	26.1	26.1	GCID Main Canal & laterals/drains, Colusa Basin Drain via Sacramento River Intertie
3	Reclamation District 108	179.8	179.8	179.8	179.8	Sacramento River Intertie to Colusa Basin Drain
3	River Garden Farms Co.	19.2	19.2	19.2	19.2	Sacramento River Intertie to Colusa Basin Drain
1	Westside WD	26.0	26.0	26.0	26.0	Tehama-Colusa Canal
1	First Priority Total	262.4	237.2	170.7	170.7	
2	Second Priority Total	340.2	340.2	340.2	340.2	
3	Third Priority Total	591.2	591.2	199.0	199.0	
	Total Demand	1,193.8	1,168.6	709.9	709.9	

Benefits would also accrue to the agricultural sector through improved water supply timing, reliability, and temperature. Users on the Tehama-Colusa and Corning Canals would benefit greatly from the increased early season availability and timing that would be the result of the project's capability of directly suppling these systems. Currently, with the raising of the Red Bluff Diversion Dam gates from September 15 through May 15 of each year, supplies become limited based on the capacity of the current pumping facility that replaces the gravity diversion. During certain periods, demands exceed supply availability. The offstream storage supplies could augment the pumped supplies to reduce the period that the gates need to be lowered for gravity diversions. Or, if one of the larger yielding projects were implemented, the necessity to lower the gates might be eliminated altogether. This would provide a huge benefit to the fisheries, but could sharply reduce the recreational benefits created by Lake Red Bluff. Finally, farmers prefer to use surface supplies that are warmer than those found within the Sacramento River, especially since there has been increased temperature regulation for fisheries with the completion of the Shasta Lake Temperature Control Device. The warmer offstream storage supply would benefit not only seed germination, but crops in general.

The benefits that could be achieved through water exchange are summarized in Table 13.

Table 13. Summary of Water Exchange Program Benefits

Agriculture	Environment	
	Refuges	Sacramento River / Delta
Improved timing	Improved timing	Reduced diversions during key migration periods
Increased reliability	Increased reliability	Improved temperature regulation throughout river
Reduced Sacramento River Diversions	Reduced diversions from Sacramento River	Reduce or eliminate lowering of Red Bluff Diversion Dam Gates

Summary

This analysis has examined the potential water purveyors that could be conveniently served from each project. Their acreage, demands, and supplies are summarized in relation to the potential project that might serve them. The yield in any one of the projects could be fully used for in-basin water demands that will offset diversions from the river. This will provide significant fishery benefits that include leaving cooler water in the river, fewer diversions with less magnitude during certain periods of the year, and changing the time period of gate closure at the Red Bluff Diversion Dam. In addition, agricultural water users would benefit from improved timing and reliability of water deliveries and warmer water.